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(54) PROCESS FOR THE COATING OF FOUNDATION ELEMENTS

(71) We, SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V. (formerly "N.V."), a company organised under the laws of The Netherlands, of 30 Carel van Bylandtlaan, The Hague, The Netherlands, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with a process for the entire or partial coating of vertical foundation elements, such as concrete or steel piles, with a layer of bitumen that is thicker than is necessary for conventional protection (against corrosive attack) purposes. The present invention also includes the resulting foundation elements.

For constructions which have to be erected on weak soils, such as clay or peat layers, vertical foundation elements are usually applied, such as concrete or steel piles. The points of these foundation elements then rest on a bearing sand layer, while in some cases, in addition, part of the weight of the construction is borne by the weak soil layers, since these exert a frictional resistance on the pile (the so-called "friction"). However, this friction only contributes to the total resistance to which the pile is subjected by the weight of the construction it bears, if these weak soil layers have sufficiently settled. If the settling process is still under way, the situation may be affected adversely. In particular on sites which have entirely or partly been elevated, downward frictional forces then occur, which results in the point of the pile being loaded additionally. The occurrence of this so-called negative friction considerably reduces the net bearing capacity of the pile. Under certain conditons the negative friction may be so great that virtually all of the bearing capacity of the point of the pile is required to compensate for this negative friction, which, obviously, is highly undesirable.

A known technique to avoid this negative friction is to coat, entirely or partly, the vertical foundation element with a layer of bitument which is thicker than is necessary for conventional protection purposes and has such a consistency and thickness that the outer layer of this coating can follow the movements of the soil without transmitting them to the foundation element, as a result of which the negative friction exerted on the pile is strongly reduced. This bitumen is not ripped off or sheared off from the foundation element (hereinafter also called "pile") when the foundation element is introduced into the soil by means of driving. The bitumens which have been recommended for this purpose have a penetration between 20 and 100, and a penetration index between —1 and +2.

In this application the term "penetration" means the number of tenths of a millimetre that a needle penetrates into the bitumen when measured according to the standard method laid down in the well-known U.S. Standard Specification: ASTM D5; the determination of the penetration index is described in the book by J. Ph. Pfeiffer "The properties of asphaltic bitumen," Elsevier Publishing Company Inc., New York, 1950, page 166.

A drawback of these bitumens is that during storage for a relatively short time they start to flow, as a result of which vertical foundation elements, such as driving piles, which have been coated with such a bitumen cannot be stored for a few days, for example over the weekend. During storage flow is then so considerable that the layer thickness of the bitumen on the foundation element is no longer homogeneous, in some places the layer being too thick and in others too thin.

A type of bitumen has now been found which not only meets the practical requirements as to reduction of the negative friction exerted on the foundation element and adhesion to the foundation element during driving, but which in addition shows so little flow that storage of foundation elements coated with this bitumen for some days is possible.

According to the present invention a process for the entire or partial coating of a vertical foundation element, such as a concrete or steel pile, with a layer of bitumen that is thicker than is necessary for conventional protection purposes, comprises coating the element with a bitumen of such a composition that the coordinates which, in a softening point — penetration diagram, denote the relationship between the softening point in degrees Centigrade as determined by the ASTM D—36 method and the penetration in tenths of a millimetre as determined by the ASTM D—5 method of the bitumen lie within the area of said diagram which is defined by a polygon with the vertices E(55, 240) F(90, 60) G(83, 20) H(79, 20) K(55, 100), the units of said vertices being, respectively, degrees Centigrade and tenths of a millimetre. These bitumens have a penetration index between +2 and +6.

By softening point is understood the softening point determined with ring and ball according to the standard method laid down in the well-known U.S. Standard Specification: ASTM D—36.

The term "bitumen" is taken to refer not only to pure bitumens, but also to mixtures of bitumens with, for example, filler and/or polymers.

In said softening point-penetration diagram the softening point has been plotted on a linear scale along the horizontal axis and the penetration on a logarithmic scale along the vertical axis. The figure shows such a diagram, which contains the polygon EFGHK with the coordinates mentioned hereinbefore.

The coordinates of the bitumen according to the invention are preferably located inside the quadrangle with the vertices A(65, 70) B(77, 50), C(73, 29) D(64, 54) (also indicated in the figure), since such bitumens show very little flow (viz. at most 1 cm upon storage for three days at 20°C, determined according to a standardized method).

The bitumen used is preferably asphaltic bitumen. If so desired, the bitumens according to the invention may also contain up to 35% filler and/or polymer; however, these mixtures should invariably meet the specifications characteristic of the present invention.

As already mentioned hereinbefore, the bituminous slip layer is thicker than is necessary for conventional protection purposes and the outer layer of the coating should be able to follow movements of the soil without transmitting forces of a significant magnitude to the foundation element. It has been found that a layer for this purpose should in general have a thickness of at least 0.3 cm. A layer with a thickness between 0.5 and 1.5 cm should be preferred.

The bitumen layer can be applied in a simple way onto the foundation element. In the case of a concrete or steel pile the surface is first provided with an adhesive coat of bitumen ("primer"). This can be done, for instance, by treating the pile with a solution of the bitumen to be used for the slip layer in a volatile hydrocarbon solvent, after which the solvent is caused to evaporate.

Subsequently, the bitumen is, for example, in the case of a pile of square or rectangular cross-section, poured onto one side of the horizontally disposed pile until the desired thickness of the coating, for example 1 cm, has been reached. The bitumen is prevented from flowing away along the adjacent sides by clamping — temporarily — laths against the vertical sides. Next, the pile is turned through 90°C and the process repeated. The sharp, right corners which result from this method of application, can be easily rounded with the aid of a warm knife.

It is also possible to place the pile, preferably provided with an adhesive coat, in an open box — the distance between the walls of the box and the sides of the pile being approximately equal to the thickness of the bitumen layer to be applied — and then to pour such a quantity of warm bitumen into the box that all sides of the pile (or the surface of a pile of circular cross-section) are covered with a layer of bitumen of the desired thickness. After having cooled down, the pile can be taken from the box.

Another possible technique is to apply bituminous sheets of the desired thickness onto the sides of the pile with the aid of a cold or warm adhesive. If necessary, in this case also the sharp, right corners can easily be rounded with a warm knife.

It is also possible to apply warm bitumen onto the pile, preferably provided with an adhesive coat, by means of spraying. After cooling this process can be repeated until the desired thickness of the bitumen coat has been reached.

The vertical foundation elements can be coated with the bitumen according to the invention over their entire length, but in many cases it suffices to coat the upper part of the foundation element entirely, or almost entirely, and to leave the lower part

uncoated, since at this level the surrounding soil layers generally show little settlement and consequently the negative friction is inconsiderable; in fact there may even be positive friction. Very suitably, the foundation element contains between the bitumen-coated and uncoated part a protective edge or collar, as described in Applicant's U.K. Patent Specification 1,365,353.

The bitumen-coated foundation elements obtained according to the invention, for example driving piles, can be stored for some length of time without the occurrence of considerable flow. This enables the foundation elements to be coated with bitumen, not on — or near — the job, but in a factory which may be located at a considerable distance from the job. This allows not only an accurate and standardized coating treatment, but also makes it attractive to employ bitumen-coated vertical foundation elements for constructions which are not very large, for which bitumen coating of the foundation elements on the spot would be too costly.

Example

Of two different bitumens, tiles of 10 x 10 x 1 cm were made. One large face of these tiles was attached to a vertical wall in such a way that it matched a vertical of this wall, whereas the other large face was marked in five places, spaced at intervals of 2.5 cm along the central vertical.

The flow was determined by measuring the vertical displacement of these marks relative to the wall.

These experiments were carried out at a temperature of 20 ± 1°C. The results have been collected in the table.

Bitumen			Flow at 20°C in cm after:			
No.	Soft.p. R & B, °C	Pen/25°C, 0.1 mm	1 day	3 days	7 days	12 days
I	73	50	—	0.07	0.12	0.16
II*	58	59	0.9	1.7	2.8	3.9

* not according to the invention

In the case of a driving pile of 40 x 40 cm, coated with a slip layer of bitumen no. 1 of 20 m length and 1 cm thickness, and at a rate of soil settlement of 10 cm per annum, the residual negative friction is only at most 4 x 10^4 N.

WHAT WE CLAIM IS:—

1. A process for the entire or partial coating of a vertical foundation element, such as a concrete or steel pile, with a layer of bitumen that is thicker than is necessary for conventional protection purposes, which comprises coating the element with a bitumen of such a composition that the coordinates which, in a softening point-penetration diagram, denote the relationship between said softening point in degrees Centigrade as determined by the ASTM D—36 method and said penetration in tenths of a millimetre as determined by the ASTM D—5 method of the bitumen lie within the area of said diagram which is defined by a polygon with the vertices E(55, 240), F(90, 60), G(83, 20) H(79,20) K(55, 100), the units of said vertices being, respectively, degrees Centigrade and tenths of a millimetre.

2. A process according to claim 1, wherein the coordinates of the bitumen lie with the area of said diagram which is defined by a polygon with the coordinates A(65, 70) B(77, 50) C(73, 29) D(64, 54).

3. A process according to either one of the preceding claims wherein an asphaltic bitumen is employed.

4. A process according to any one of the preceding claims wherein the thickness of the layer applied is between 0.5 and 1.5 cm.

5. A process according to claim 1 substantially as hereinbefore described with reference to the Example.

6. A vertical foundation element, such as a concrete or steel pile, which is coated with a layer of bitumen according to the process claimed in any one of the preceding claims.

7. A foundation element which is entirely or partially coated with a layer of bitumen that is thicker than is necessary for conventional protection purposes, said bitumen being of such a composition that the coordinates which, in a softening point penetration diagram, denote the relationship between said softening point in degrees Centigrade as determined by the ASTM D—36 method and said penetration in tenths of a millimetre as determined by the ASTM D—5 method of the bitumen lie within the area of said diagram which is defined by a polygon with the vertices E(55, 240), F(90, 60), G(83,20), H(79, 20), K(55, 100), the units of said vertices being, respectively, degrees Centigrade and tenths of a millimetre.

8. a Foundation element according to claim 7 substantially as hereinbefore described with reference to the Example.

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PLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale